Recent Improvements in Surface-Only Flux Algorithms (SOFA) (Simple Surface Flux Models)

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Background

- CERES uses several simple surface flux models for computing SW and LW surface fluxes in addition to the detailed model used by SARB. These models are:

LPSA/LPLA:
Langley Parameterized SW/LW Algorithm

		Model A	Model B	Model C
SW	Clear	Li et al.	LPSA	--
	All-Sky	--	LPSA	--
LW	Clear	Inamdar and Ramanathan	LPLA	Zhou-Cess
	All-Sky	--	LPLA	Zhou-Cess

References:

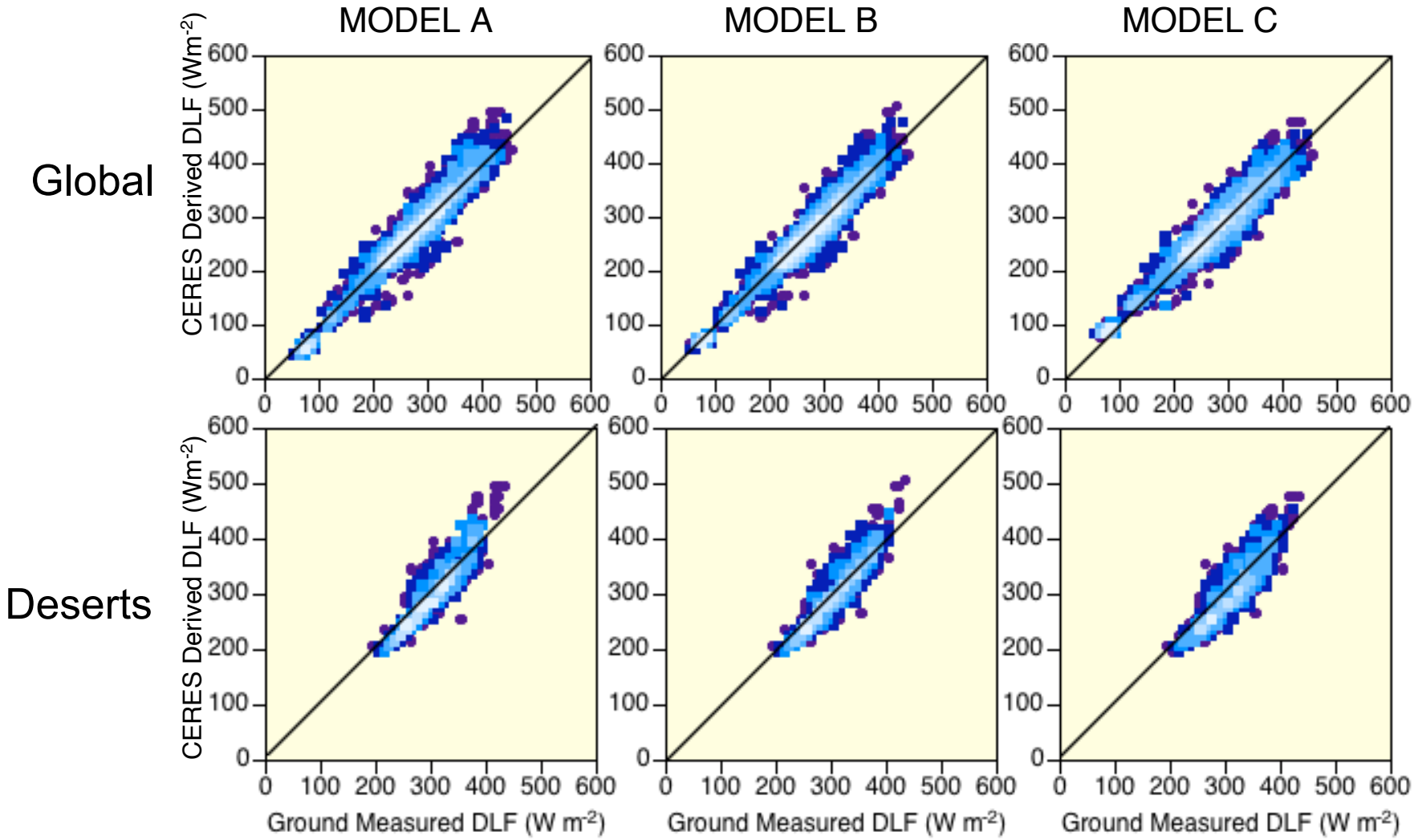
SW A: Li et al. (1993): *J. Climate*, **6**, 1764-1772.
SW B: Darnell et al. (1992): *J Geophys. Res.*, **97**, 15741-15760.
Gupta et al. (2001): *NASA/TP-2001-211272*, 31 pp.
LW A: Inamdar and Ramanathan (1997): *Tellus,* **49B**, 216-230.
LW B: Gupta et al. (1992): *J. Appl. Meteor.,* **31**, 1361-1367.
LW C: Zhou and Cess (2001): *J. Geophys. Res.,* **106**, 12477-12488.
Zhou et al. (2007): *J. Geophys. Res.*, **112**, D15102.

Background (contd.)

- These models are fast parameterizations for TOA-to-Surface transfer algorithms; have been around and have been validated.
- The purpose of these models is to produce surface fluxes quickly, and in the process, keep a check on SARB results.
- SW and LW Models A and B used since the beginning. Good results and validation shown for all Editions of TRMM and Terra data at earlier STMs. Also for Aqua-1A and -1B data.
- LW Model C introduced recently; Tested thoroughly. Will be used starting with Edition-3 processing.
- Focus of this presentation concerns improvements made recently to all three LW models (A, B, and C), which were overestimating DLF for some footprints at the high end of DLF range.

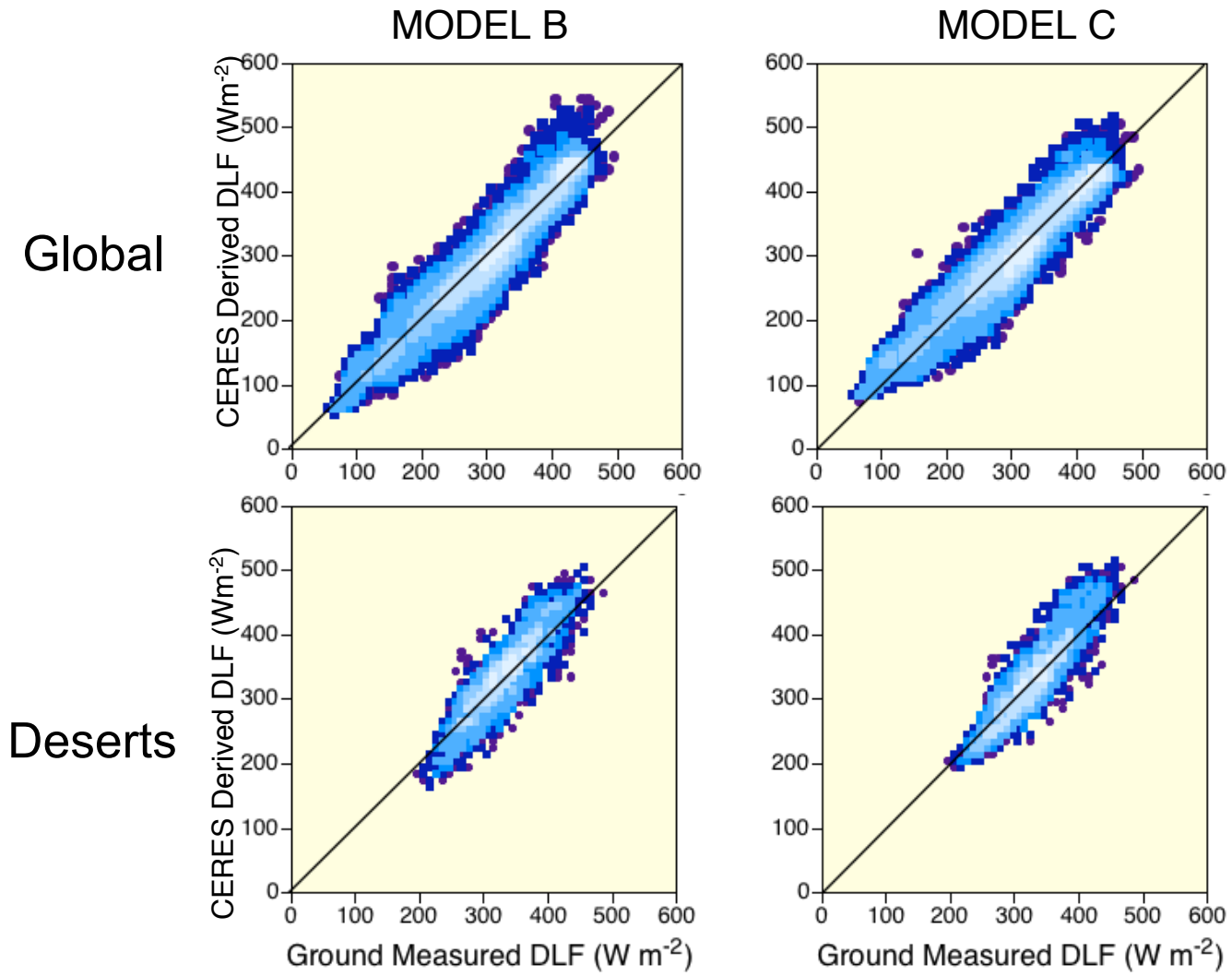
Overestimation of DLF Over Desert Regions

Clear-Sky (Aqua-2A; July 2002 - March 2005)



Overestimation of DLF Over Desert Regions

All-Sky (Aqua-2A; July 2002 - March 2005)



Cause of Overestimation and Remedy

- Started to look for the cause of overestimation in LW Model B.
- Determine the cause, develop remedies, and apply to all models.
- Effective Emitting Temperature:

$$T_{eff} = 0.60\ T_s + 0.35\ T_1 + 0.05\ T_2$$

T_s - Surface skin temperature
T_1 - Average temperature for Sfc. - 800 mb layer
T_2 - Average temperature for 800 - 680 mb layer

- Works well when T_s, T_1, and T_2 conform to nominal lapse rates.
- When $T_s >> T_1$ (and T_2), it results in overestimation of DLF.
- Happened mostly over dry/arid regions during hot times of the day.

Further Study of Overestimation

- Selected two sites for study:

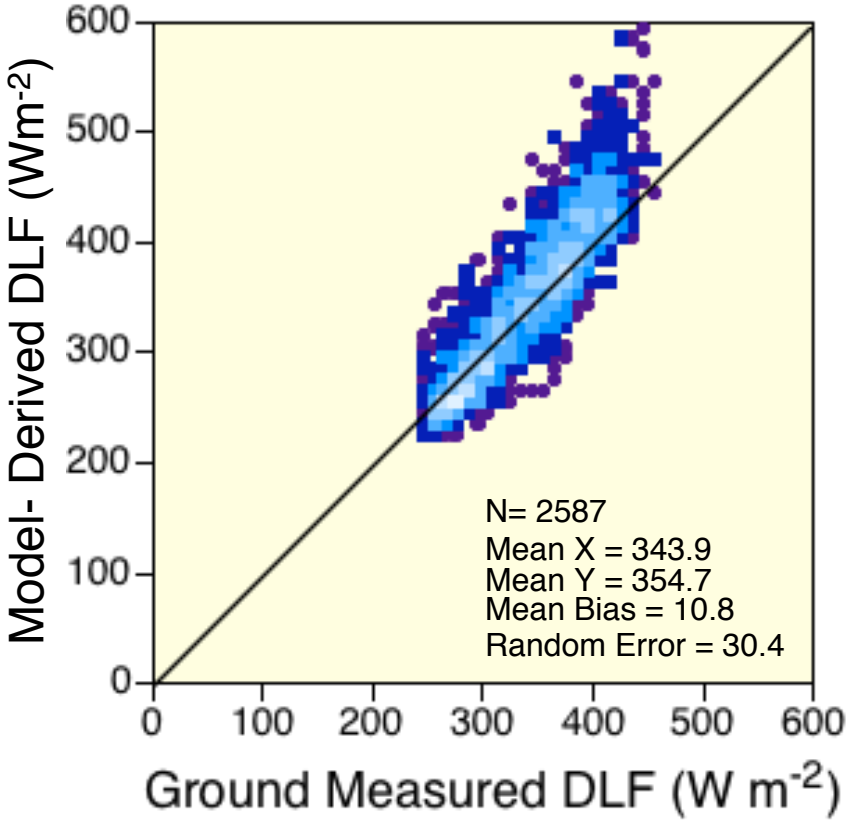
  Alice Springs, Australia - Dry/Arid
  Goodwin Creek, MS (USA) - Moderate/Humid

- Performed flux computations using an offline version of the model on a 3-hourly time resolution for all months of 2000.

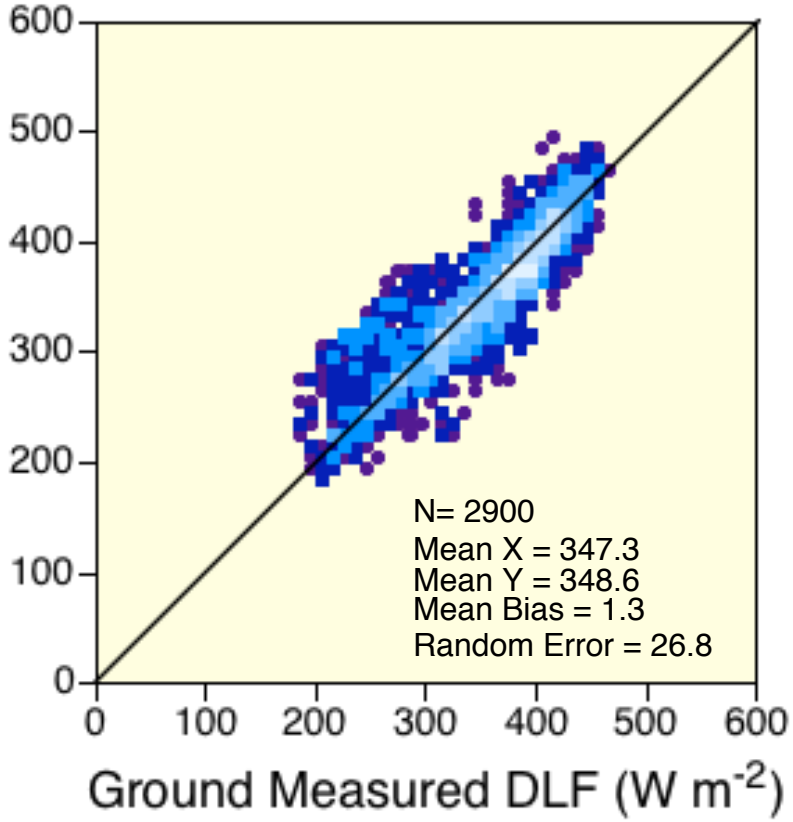
- Compared model-derived DLF with ground-based observations for the above sites obtained from BSRN database.

Model-Derived vs. Ground-Measured BSRN DLF
(Offline LW Model B)

Alice Springs

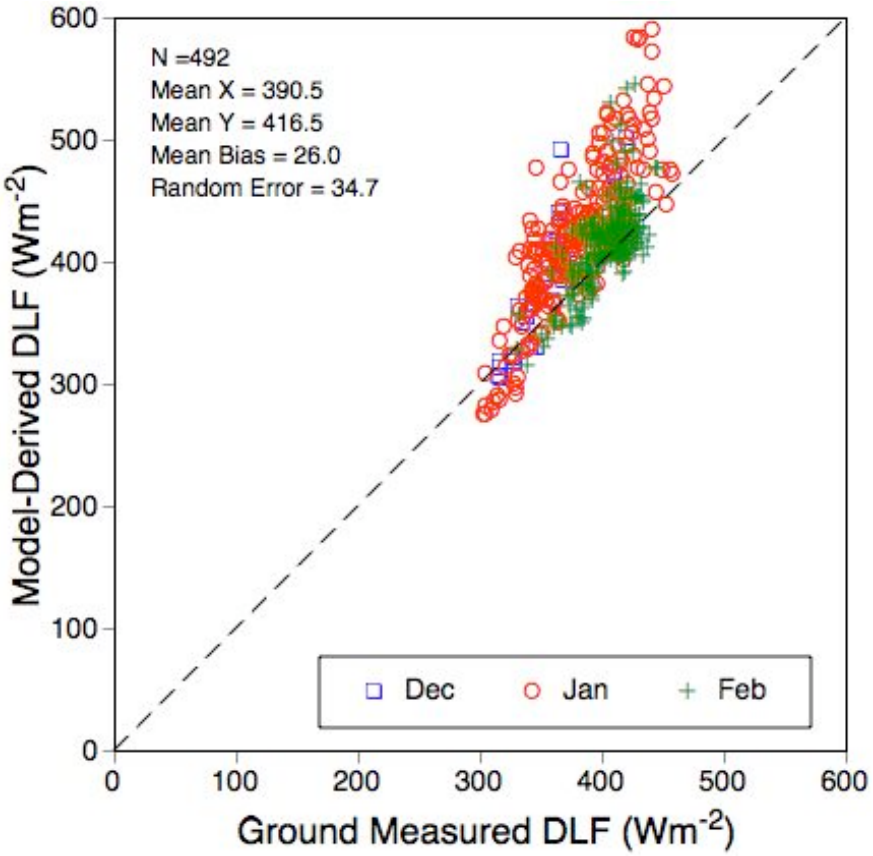


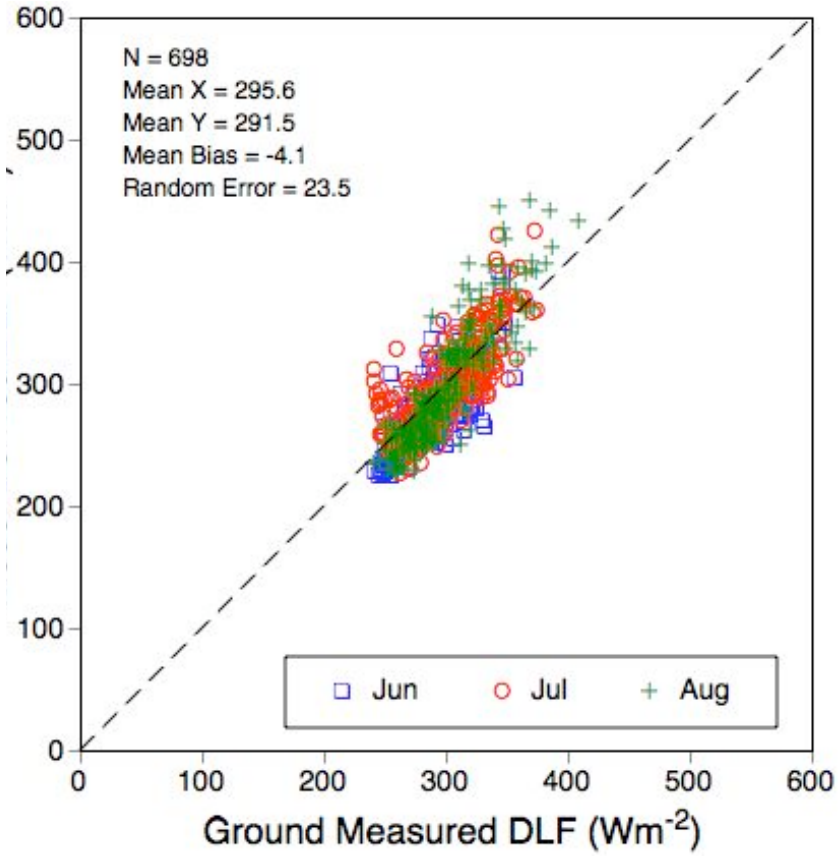
Goodwin Creek



Significant overestimation over Alice Springs; almost none over Goodwin Creek

Model-Derived vs. Ground-Measured DLF
(Offline LW Model B)
Alice Springs





Severe overestimation during DJF; slight underestimation during JJA

Analysis of Alice Springs Overestimation

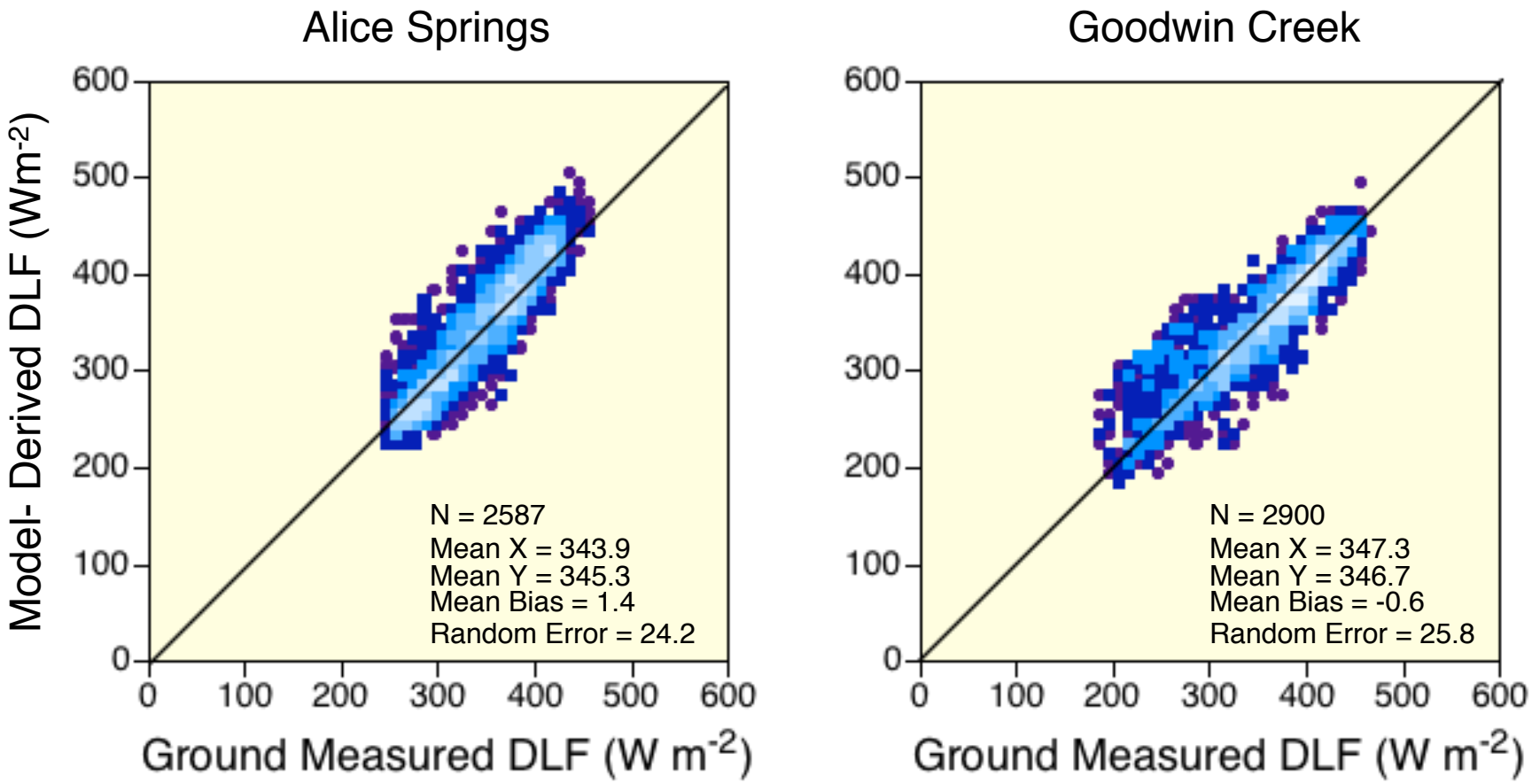
- Points with overestimation of > 100 Wm^{-2}
  - 32 points during the year (16 in Jan; 20 in DJF)
  - Mean = 120 Wm^{-2}; Range: 100-160 Wm^{-2}
  - T_s: Mean = 324.3 K; Range: 302-336 K
  - P_s: Mean = 939 mb; Range: 935-946 mb
  - T_{800}: Mean = 292.1 K; Range: 284.7-297.7 K
  - $T_s - T_{800}$: Mean = 32.2 K; Range: 17.0-40.3 K

- $T_s - T_{800}$ should be about 10 K, but no more than 15 K

- Decided that lapse rates > 10K/100mb in the lower layer are too steep, and need to be adjusted.

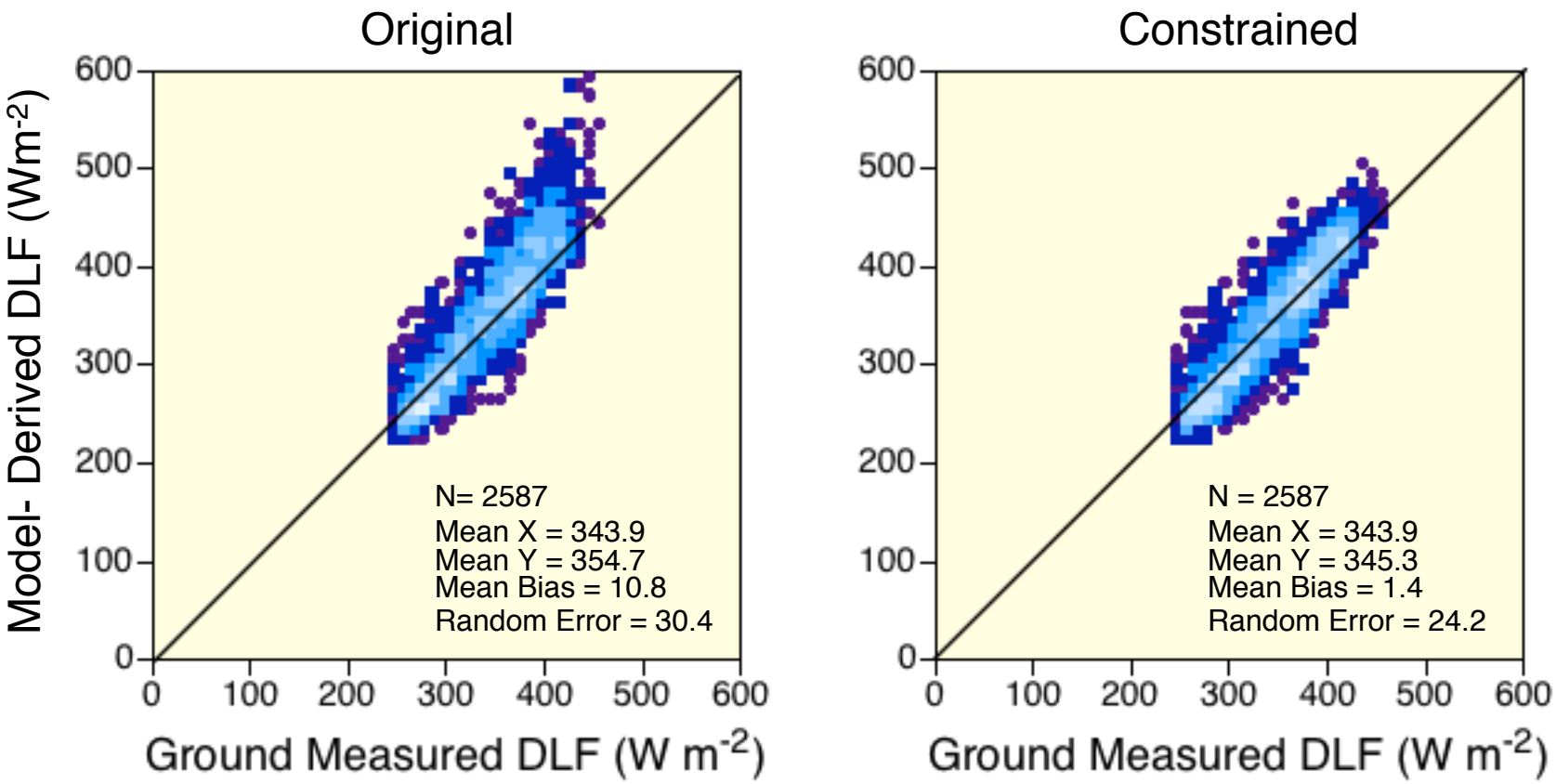
- Adjusted skin temperature to not exceed 10K/100mb limit.

Results From the Modified Computation



Bias for Alice Springs - reduced greatly; Change for Goodwin Creek - minimal

Original and Constrained Computation - Alice Springs



Bias for Alice Springs is greatly reduced

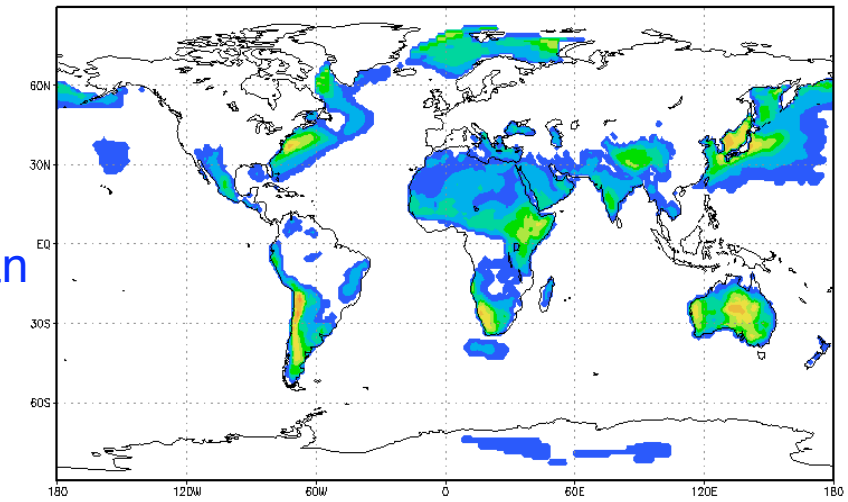
Monthly Temperature Adjustment and Frequency

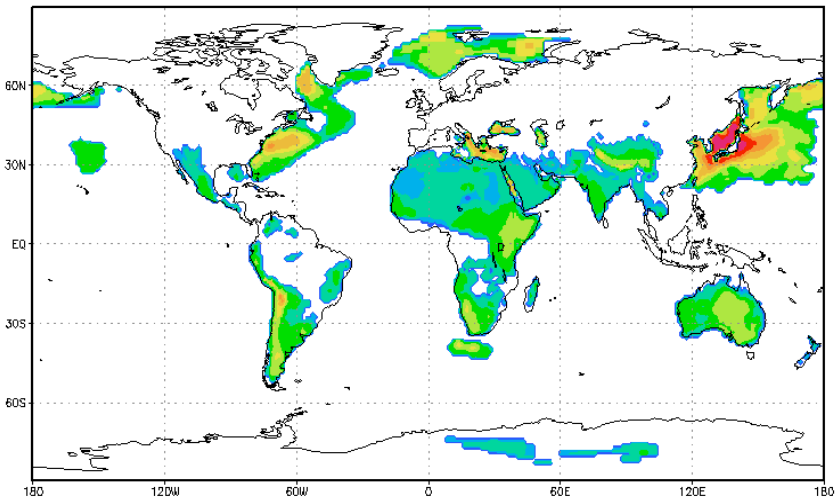
Temperature Adjustment

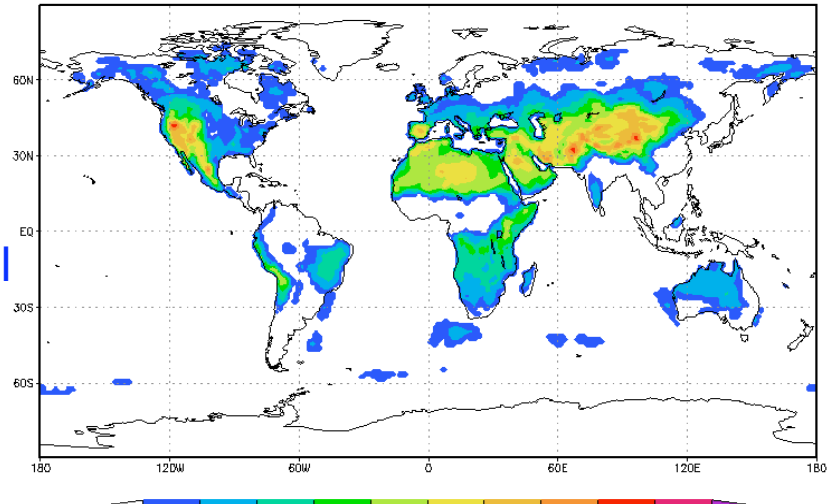
Adjustment Frequency

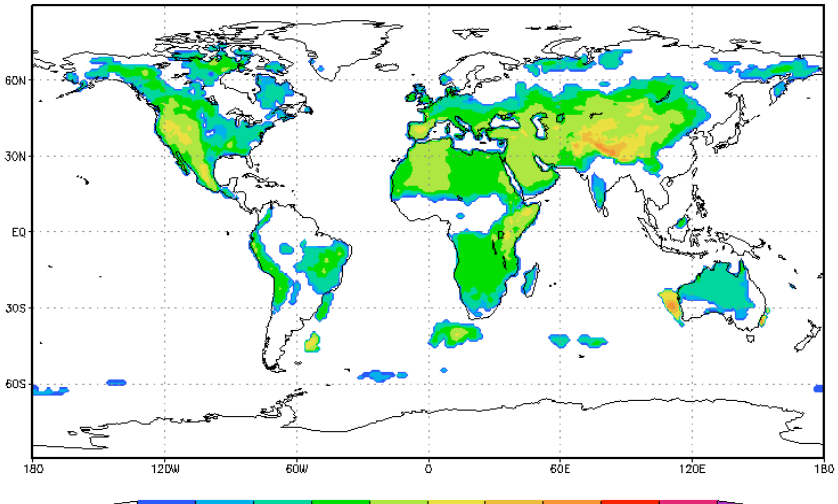
Jan

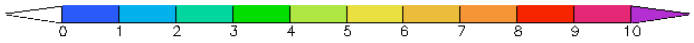
Jul

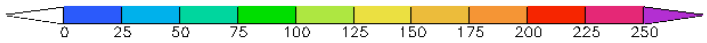












Application to LW Model C

$$SDLW(clr) = a0 + c1*SULW + c2*\ln(1+PWV) + c3*[\ln(1+PWV)]^2$$

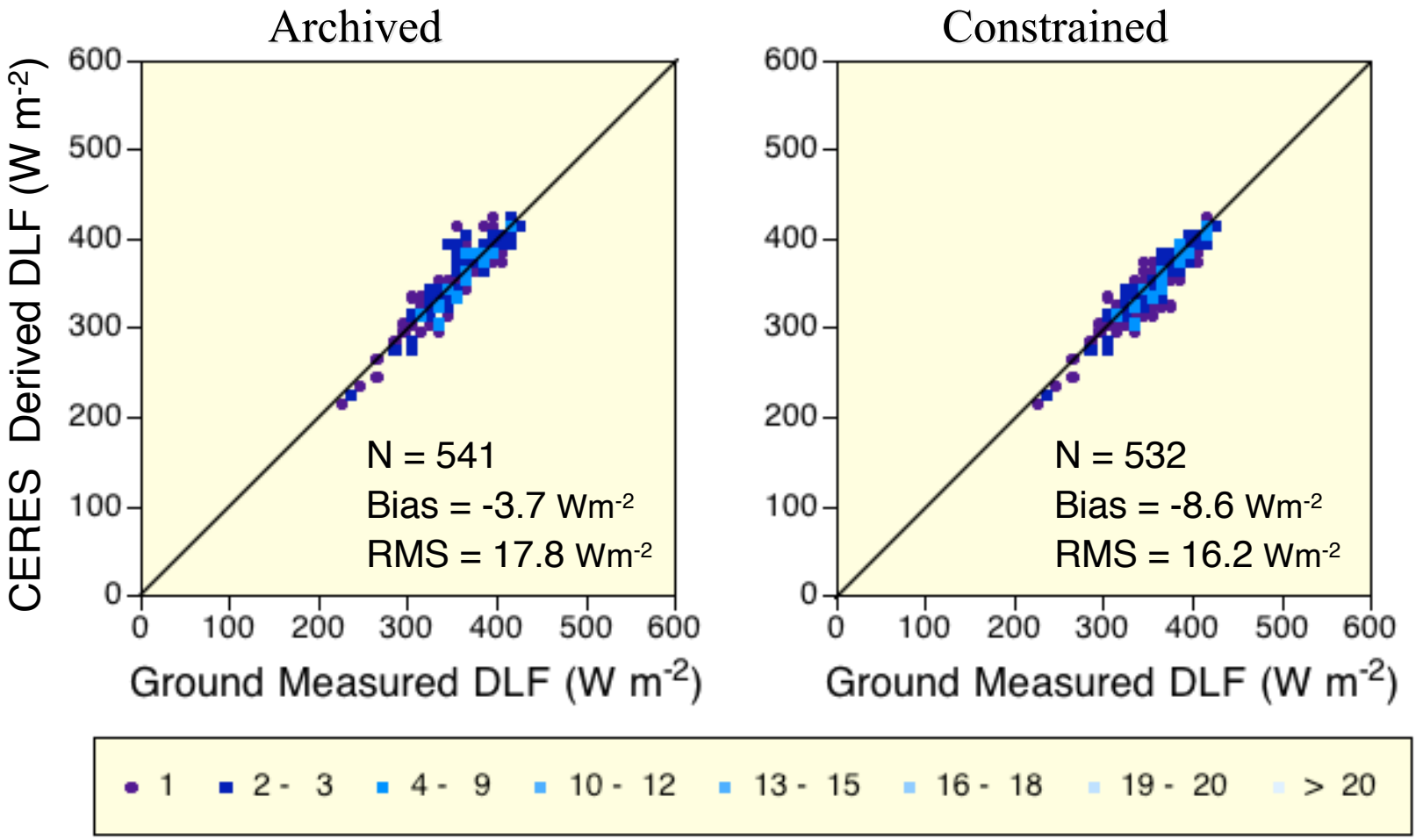
$$a0 = 37.687,\ c1 = 0.474,$$
$$c2 = 94.190,\ c3 = -4.935$$

$$SULW = \sigma * T_s^4$$

Use Adjusted Skin Temperature

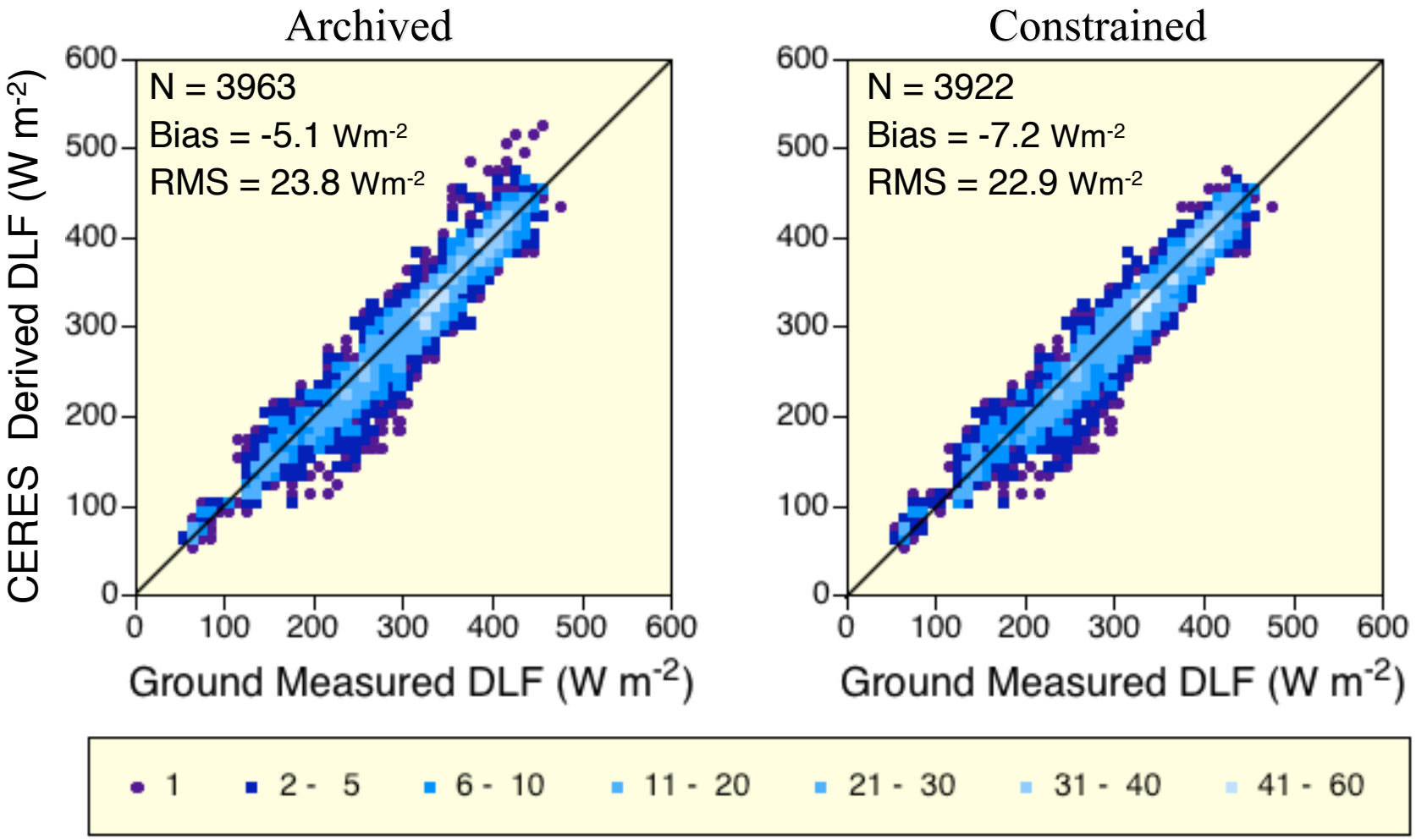
Longwave Model A

January & July 2004 - Aqua & Terra



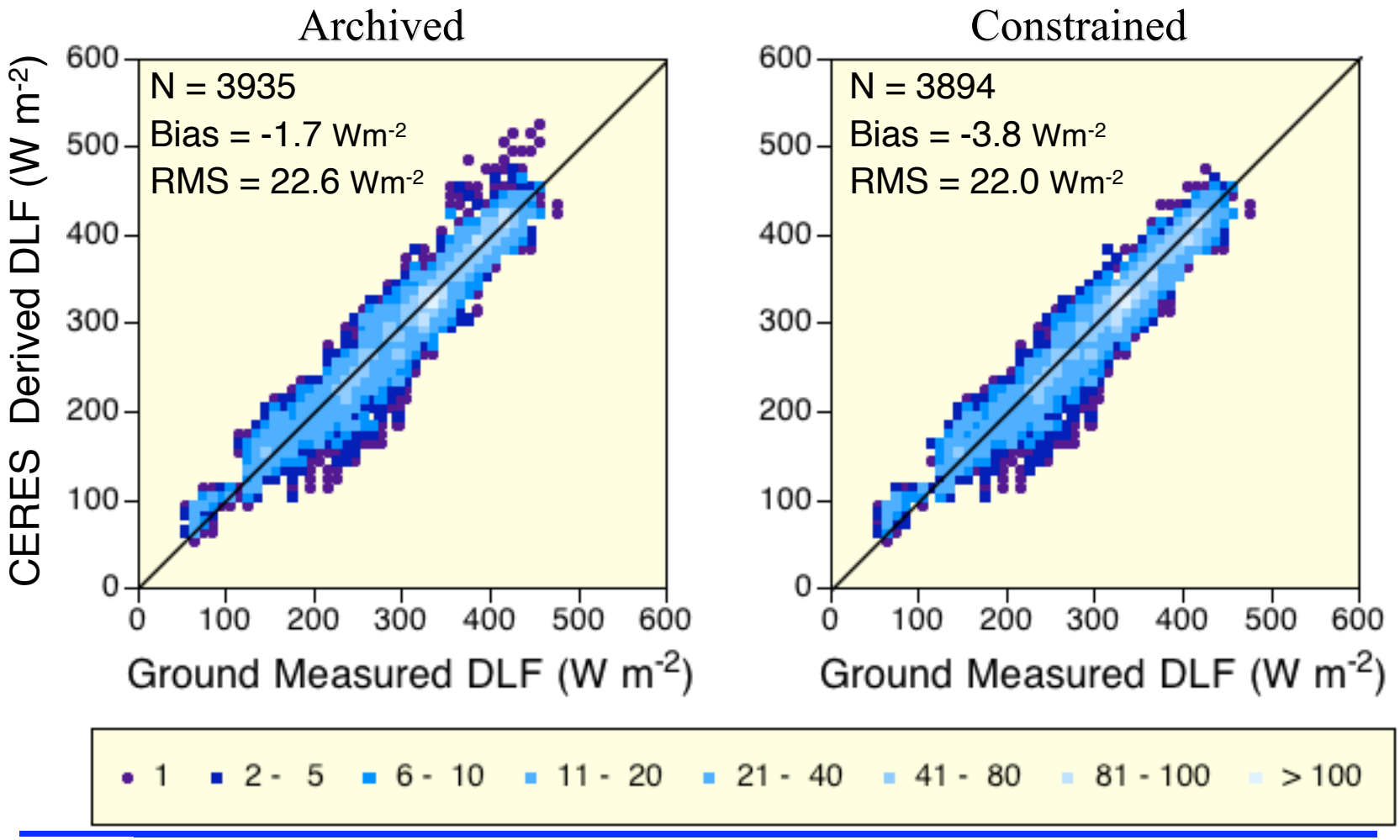
Longwave Model B

January & July 2004 - Aqua & Terra



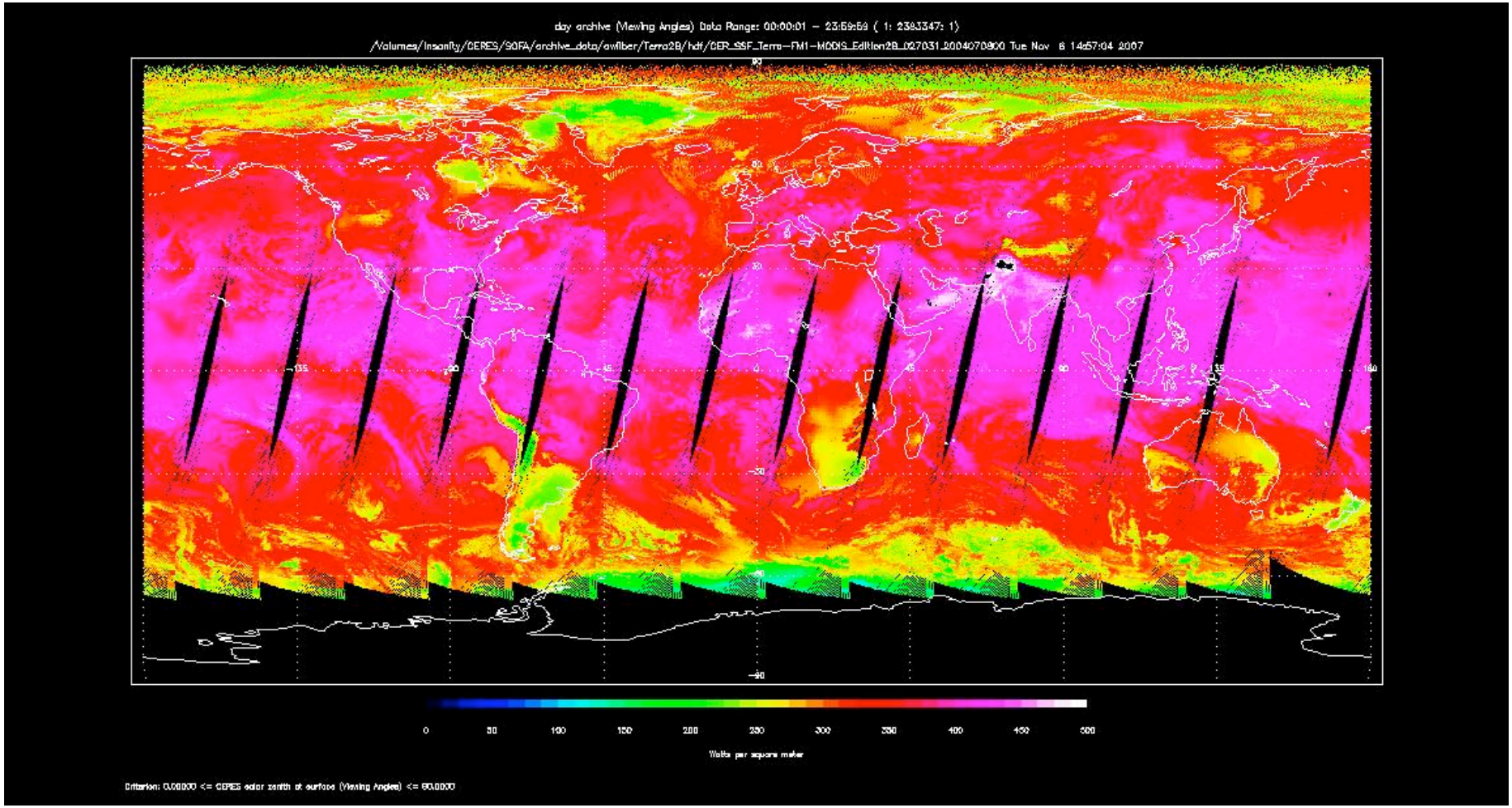
Longwave Model C

January & July 2004 - Aqua & Terra



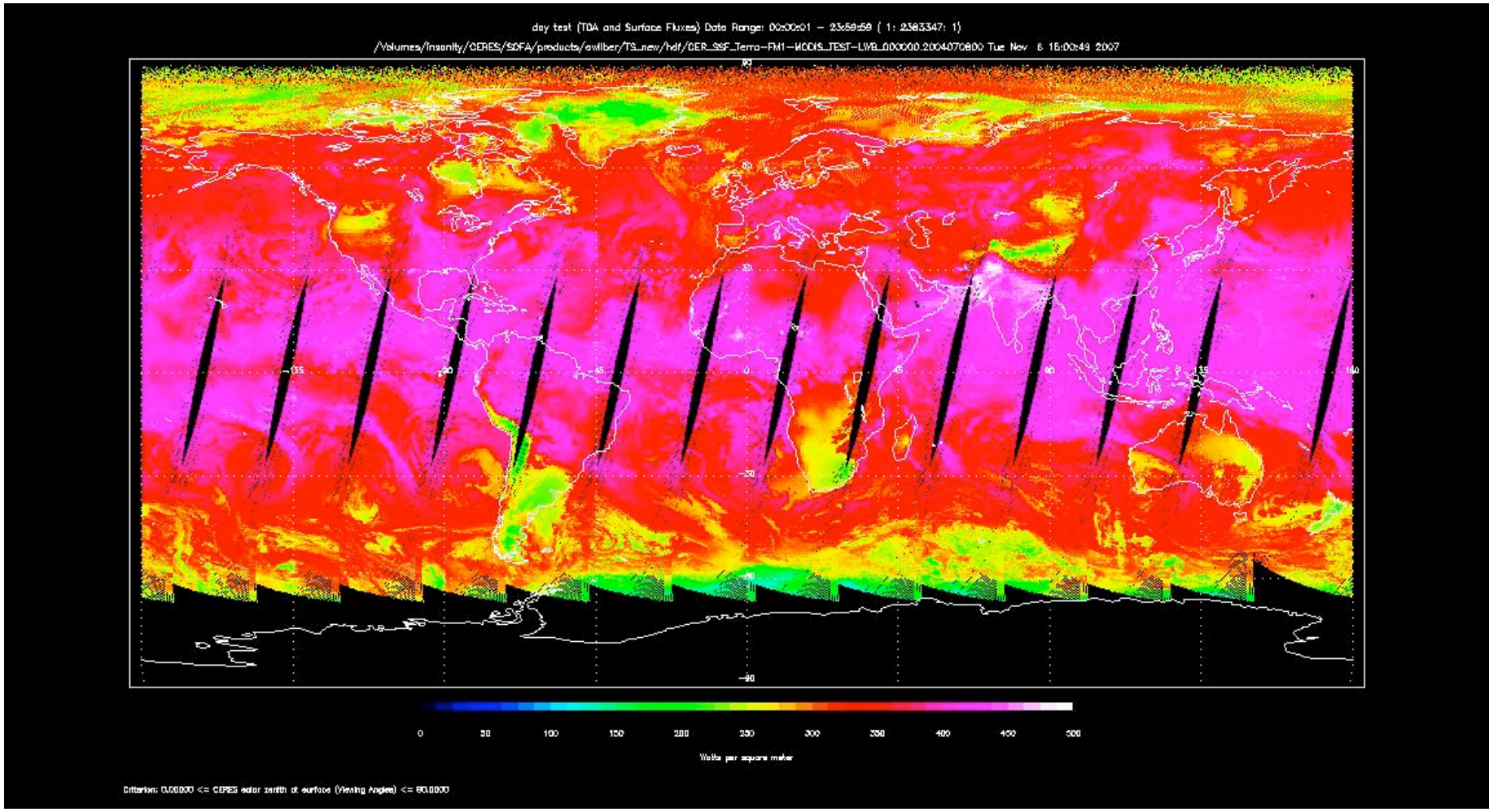
Downward Longwave Model B With MOA Ts

08 July 2004 - Terra - Daytime Overpasses



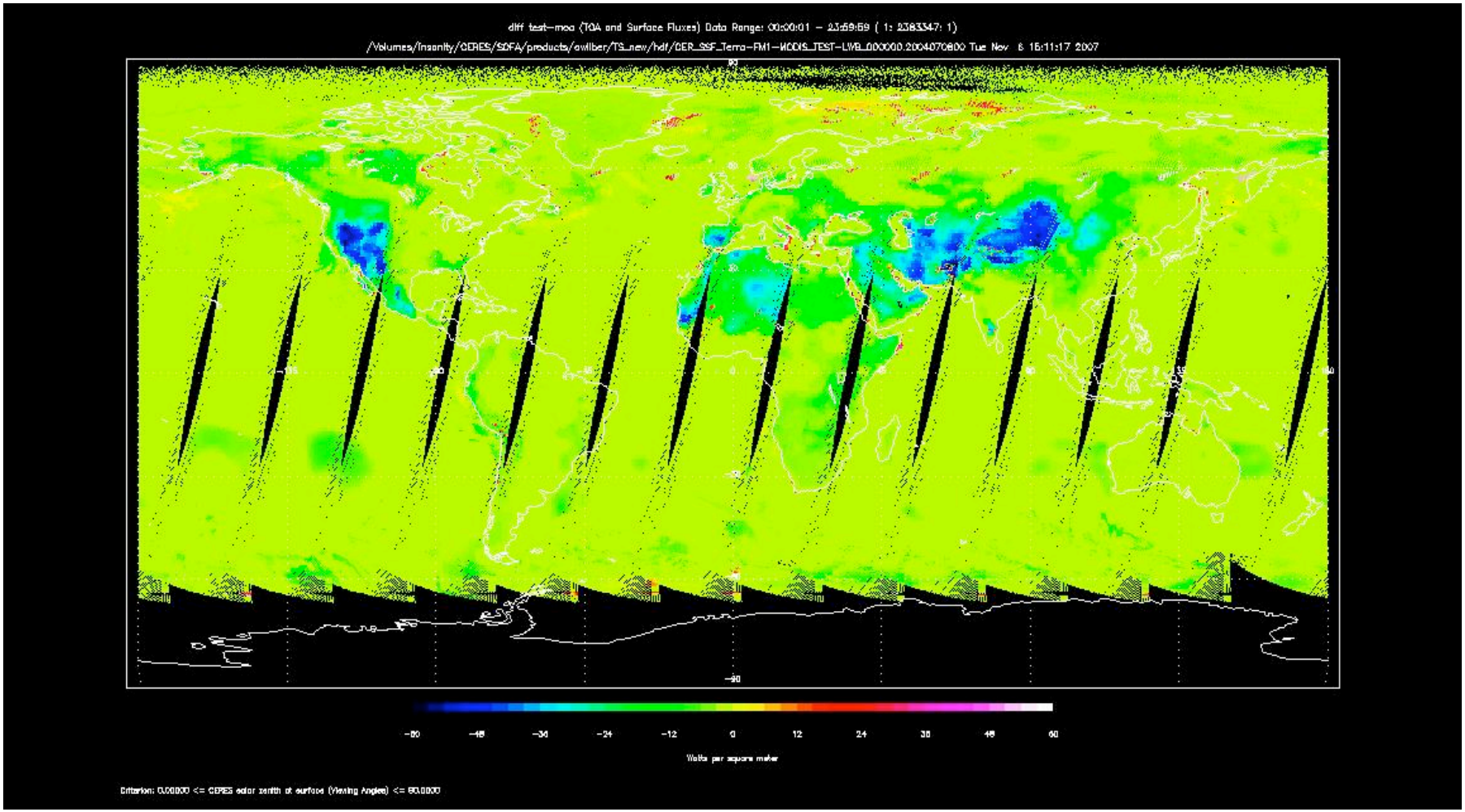
Downward Longwave Model B With Constrained Ts

08 July 2004 - Terra - Daytime Overpasses



Downward Longwave Difference Model B

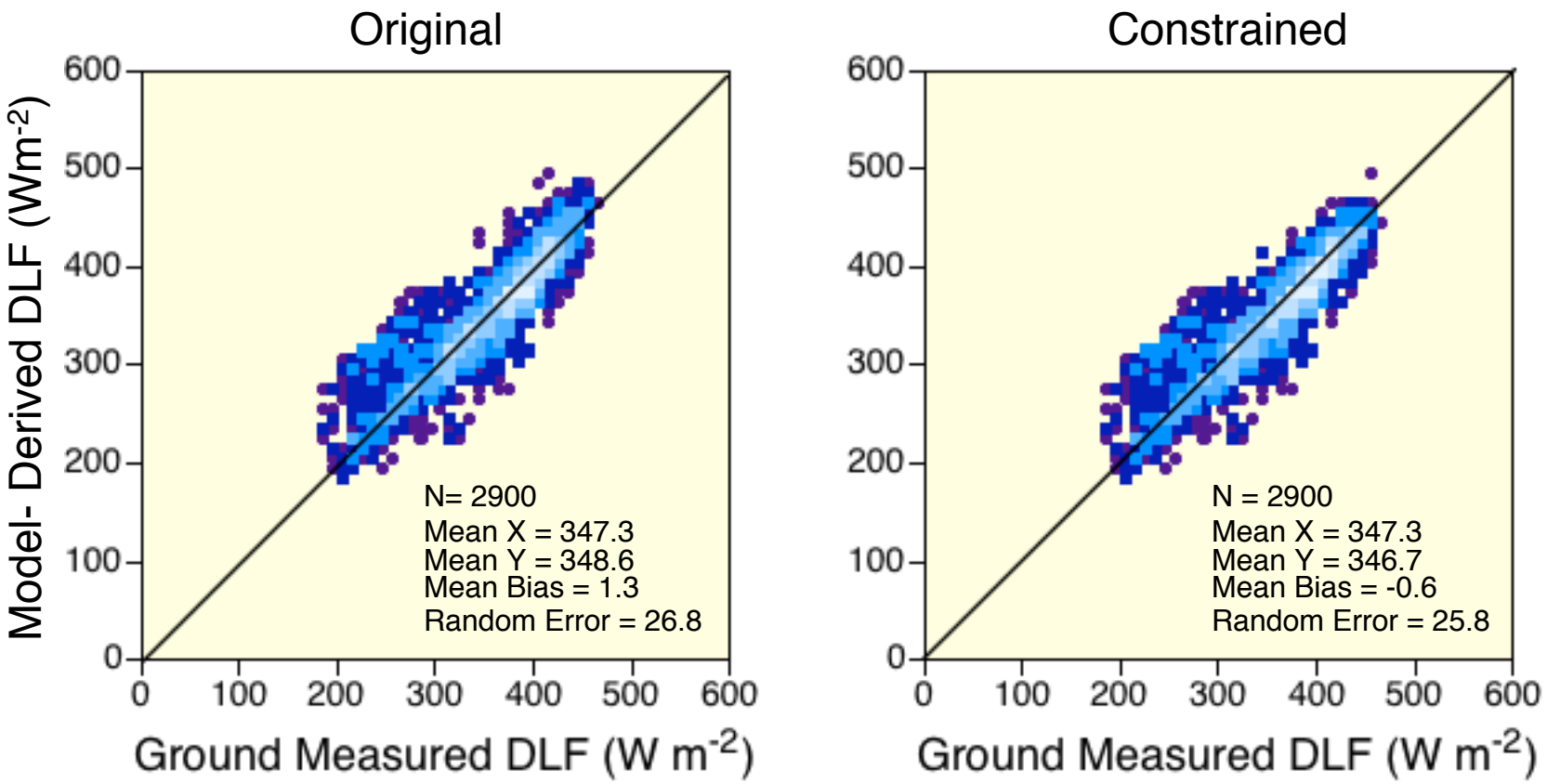
08 July 2004 - Terra - (Constrained - Original)



Summary

- Determined the cause of DLF overestimation: Occurs when skin temperature (T_s) is much higher than atmospheric temperatures.
- Developed a method for detecting this condition and constraining T_s prior to using it in DLF computation. Constrained T_s is not used for upward flux computation.
- Tested the method with Model-B for all months of 2000 using an offline version.
- Applied the method to CERES versions of all three models and tested for Jan and Jul 2004 for both Terra and Aqua.
- This method remedies the overestimation. Ready to be implemented in Edition-3 β-testing and final processing.

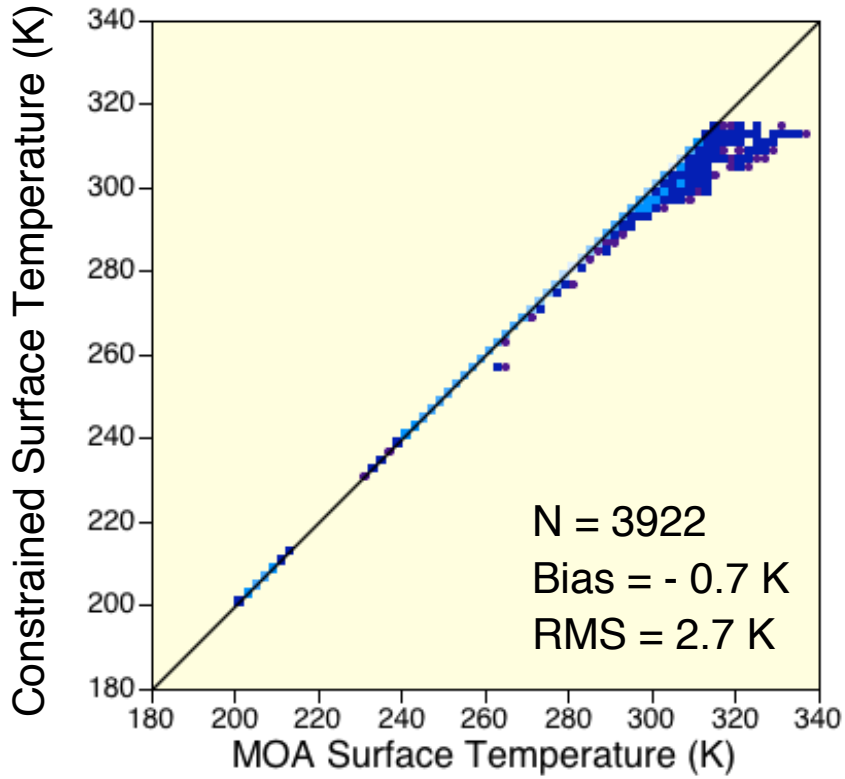
Original and Constrained Computation - Goodwin Creek

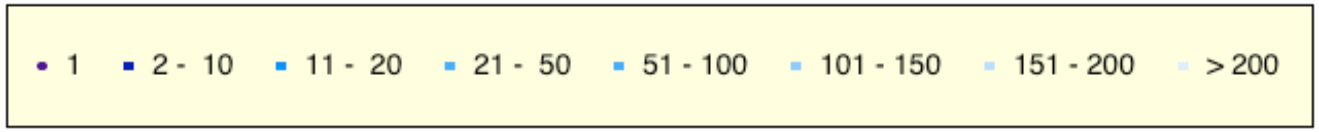


Bias for Goodwin Creek is not affected much

Ts constrained vs Ts MOA

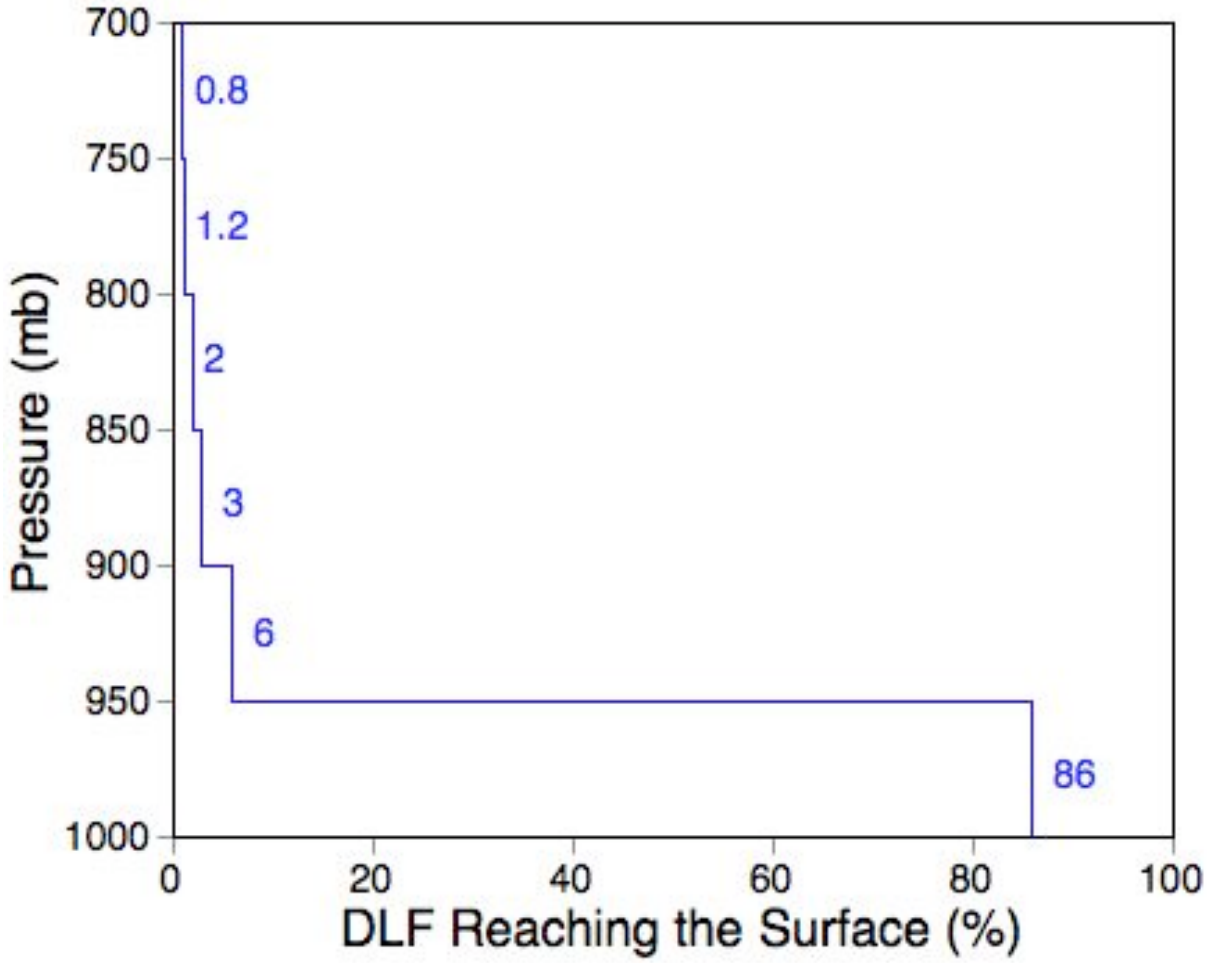
January & July 2004 - Aqua & Terra





Weighting Function for DLF Reaching the Surface

(U.S. Standard Atmosphere - 50 mb Layers)



Surface and Atmospheric Temperatures Over Sea of Japan

January 2000